

TRAFFIC SIGNAL DESIGN MANUAL



**MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION -
TRAFFIC MANAGEMENT DIVISION
2901 W. DURANGO STREET- PHOENIX, ARIZONA 85009**

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1. GENERAL INFORMATION

This section provides general information regarding the design of traffic signals within Maricopa County jurisdiction.

A. ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans With Disability Act
ANSI	American National Standards Institute
AWG	American Wire Gage
IMSA	International Municipal Signal Association
ITS	Intelligent Transportation System
LED	Light Emitting Diode
MUTCD	Manual on Uniform Traffic Control Devices
NEC	National Electrical Code
SP/BBS	Service Pedestal / Battery Back-Up System
UPS	Uninterrupted Power Supply

B. DEFINITIONS

Accessible Pedestrian Signal: A device that communicates information about a pedestrian timing in a non-visual format, such as audible tones, verbal messages and/or vibrating surfaces.

Actuation: The presence of a vehicle or pedestrian as indicated by an input to the controller from a detector. Actuation causes a detector to generate a call to the signal controller, from a vehicle or pedestrian.

Advance Detection: A detection area in advance of an intersection that detects a vehicle's passage, and is typically used to extend the green interval.

Aerial Mount: A signal mounting arrangement where the signal head is mounted overhead of the roadway on a signal pole mast arm. An aerial mount is also known as an elevated plumbizer and is designated as a Type II mount or Type 2 mount. When designating mount type with roman numerals, the numeral shall be shown using the Times New Roman font; regular numbers are to use Arial font.

Approach: All lanes of traffic moving toward an intersection.

Backplate: A strip of metal extended outward parallel to the signal face on all sides of the signal housing to provide a background for improved visibility of the signal indications.

Beacon: A roadway signal with one or more signal sections that uses a single color and operates in a flashing mode.

Cabinet: An outdoor enclosure for housing electrical equipment.

Cabinet Foundation: The foundation on which a cabinet is located. The foundation typically

includes anchor bolts for attachment of the cabinet. Conduit sweeps extend through the foundation from the cabinet into the ground.

Call: A demand for service registered in a controller. A call indicates a vehicle or pedestrian is waiting for a green indication.

Call Loop: A loop that detects a vehicle and indicates the vehicle's presence.

Clear Zone: The unobstructed, hazard free area provided beyond the edge of a traveled way for the recovery of errant vehicles. Clear zone requirements are identified in the MCDOT Roadway Design Manual.

Conduit Run: An underground conduit between pull boxes and foundations. Multiple conduit runs in the same trench are given one conduit run number.

Controller: The device that determines which signal indications are to be illuminated at any given time. The controller is usually located in a cabinet near the intersection.

Countdown Timer: A pedestrian signal head that includes a down-counting digital count of seconds left until the pedestrian head indicates solid red (do not enter the street).

Detector: A device that provides an input to the controller to indicate that a vehicle or pedestrian is present.

Emergency Vehicle Pre-Emption Detector: A device that detects a request from emergency vehicles for priority control of an intersection.

Flasher: A device used to open and close signal circuits at a repetitive rate.

Flasher Control Assembly: A complete electrical mechanism for operating a hazard identification beacon or intersection control beacon.

Free Flow: Traffic flow which is not impeded.

Fully Actuated Controller: A controller unit which accommodates traffic actuation on all approaches to the intersection.

Hawk Crossing: A pedestrian hybrid beacon that utilizes flashing yellow and red indications to supplement a pedestrian crossing. HAWK is an acronym for High intensity Activated cross Walk.

Intersection Leg: The roadways entering or leaving one side of the intersection.

Interval Sequence: The operation of appearance of signal indications during successive intervals of a cycle.

Lead-in Cable: Cable between the controller cabinet and an embedded loop detector.

Loop Detector: A sensor located in the roadway pavement that detects the passage or presence

of a vehicle.

Louver: A device that can be mounted inside a signal visor to restrict visibility of a signal indication to a certain lane or lanes.

Luminaire: A complete lighting fixture consisting of a lamp or lamps together with the ballast, reflector, refractor, photocell when required, and the housing.

Major Street: Street that carries higher volume of vehicular traffic at an intersection.

Minor Street: Street that carries the lower volume of vehicular traffic at an intersection.

MCDOT Traffic Signal Phasing Diagram: A diagram illustrating traffic movements at a signalized intersection that utilizes standard movement designations.

Pedestrian Phase: A traffic phase allocated exclusively to pedestrian traffic.

Pedestrian Push Button: A button to request a pedestrian "WALK" interval.

Pedestrian Signal Indication: The illumination of a pedestrian signal lens or equivalent device.

Phase: The part of a cycle allocated to any combination of traffic movements receiving the right-of-way simultaneously during one or more intervals, i.e. a left turn phase.

Point of Service: The location of the electrical service equipment associated with a traffic signal, or the location where electrical connection is made to the power company distribution system.

Pre-Emption: The transfer of the normal control of signals to a special signal control.

Side Mount: A signal mounting arrangement where the signal head is mounted to the side of the signal pole. Side mount is also designated as a Type XI mount or Type 11 mount. When designating mount type with roman numerals, the numeral shall be shown using the Times New Roman font; regular numbers are to use Arial font.

Signal Face: That part of a signal head provided for controlling traffic in a single direction. Turning indications (arrows) may be included in a signal face.

Signal Head: An assembly containing one or more signal faces.

Stop Bar: A pavement marking that indicates where vehicles should begin to cue for a red traffic signal indication.

Traffic Control Signal (Traffic Signal): A type of highway traffic control device that is manually, electrically, or mechanically operated, whereby traffic is alternately directed to stop and permitted to proceed.

Traffic Phase: A part of the cycle allocated to any traffic movements receiving the right-of-way or to any combination of traffic movements receiving the right-of-way simultaneously during

one or more intervals.

Type 'F' Signal Head: Signal indication consists of three circular sections, facing in the same direction.

Type 'F' Modified Signal Head: Signal indication consists of 2-red and 1-yellow signal faces, facing in the same direction.

Type 'G' Signal Head: Signal indication of three circular sections and one arrow section, facing in the same direction.

Type 'Q' Signal Head: Signal indication consists of three circular sections, one yellow section with arrow, and one green section with arrow, facing in the same direction.

Type 'R' Signal Head: Signal indication consists of three arrow sections, facing in the same direction.

Vehicular Phase: A traffic phase allocated to vehicular traffic.

Video Detection: Vehicle detection accomplished through the use of machine vision technology.

C. REFERENCES FOR DESIGN AND CONSTRUCTION OF TRAFFIC SIGNALS

Design and construction shall be in accordance with the latest edition and the most current revision and all updates as may become available for the following.

1. MCDOT Roadway Design Manual.
2. Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) as distributed by the U.S. Department of Transportation, Federal Highway Administration, as amended and approved by the Arizona Department of Transportation.
3. Maricopa Association of Governments' Uniform Standard Specifications and Details for Public Works Construction as modified by the MCDOT Supplement.
4. National Electric Code.

D. LIGHTING DESIGN AT SIGNALIZED INTERSECTIONS

This manual is not intended to be a street lighting design manual; however, intersection lighting shall be included as a part of traffic signal designs.

E. TRAFFIC SIGNAL PLANS

Construction Plan sheets shall adhere to requirements of the Maricopa County Roadway Design Manual and the MCDOT CADD Standards. The MCDOT CADD Standards are available on the MCDOT website: <http://www.mcdot.maricopa.gov/cad/cadd-support.htm>. Example plan sheets are also available on the website.

Traffic signal plans shall use the Traffic Signal Symbols contained in MCDOT Detail 4701.

Traffic signal plans shall contain Traffic Signal Plan sheets, Pole Location/Schedule and

Conductor Schedule Sheet, and Detail Sheets as needed.

1. Traffic Signal Plan Requirements

The Signal Plan shall show the proposed intersection geometry, the traffic signal installations, be drawn to a scale of 1"=20'. Traffic Signal plans shall show the existing intersection geometrics, existing and proposed utilities, striping, right-of-way lines and dimensions, jurisdictional boundaries within the intersection. All existing signal equipment is to be shown on the plan. When inductive loops are existing show dimensions, phasing, and setback from stop bars.

Traffic Signal plans shall contain the following elements:

- a. MCDOT Traffic Signal Phasing Diagram (vehicle and pedestrian).
- b. Speed Limit Table (Show the street names and speed limit).
- c. North Arrow (Orientation top or right of sheet).
- d. Graphical scale.
- e. Blue Stake Emblem.
- f. Point of Service
- g. Electrical Conduit Table - Filled out with the conduit callout numbers, size of conduit, length of the conduit, and type of conduit installation.
- h. Signal demolition notes (If applicable).
- i. Pull Box Tables - Filled out with the stationing, offsets, elevations, for each pull box size (number 3½, 5, 7 and 7 with extension).
- j. Pole Foundation Table - Filled out with the type of pole, stationing and offset, and top of pole foundation elevation.
- k. Control Cabinet and Service Pedestal / Battery Back-up Foundation Tables - Filled out with the type of foundation, stationing, offset, and elevation.
- l. Estimated Quantity Table - Showing quantities of conductors, pull boxes, pole foundations, loop and video detection.

MCDOT standard phasing shall be used. Movements are orientated to align phases 2 and 6 with the major street. For a street with an east-west major street, Phase 2 is eastbound. Phase 6 will be westbound. If the major street is orientated north-south Phase 2 is southbound. Phase 6 is northbound. The geographic orientation of phasing is shown in Figure 1-1. When the major street is not clearly evident MCDOT Traffic Management Division will identify the phasing orientation. The Phasing Diagram is to show both vehicle and pedestrian movements.

Show the phase designation for signal and pedestrian heads.

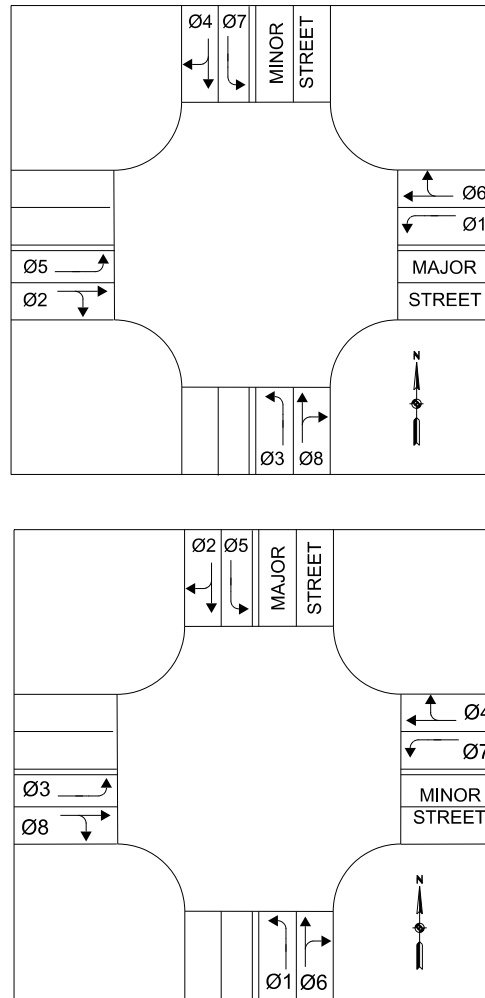
2. Pole Location/Schedule and Conductor Schedule Plan Requirements

The Pole Location/Schedule and Conductor Schedule Plan shall contain the following:

- a. Pole Location and Schedule Table shall callout out the type of traffic signal pole with the stationing and offset.

- b. Show the signal indication symbols with the type of mounting, phase and signal indication type.
- c. Pole and mast arm symbols.
- d. Video detection symbols and callouts.
- e. Luminaire symbol. Callout the type of lighting fixture and length of luminaire mast arm.
- f. Signal communication symbols and callout (If applicable).
- g. Controller Cabinet Assembly Table – Completed.
- h. Electrical Power Source Table – Completed.
- i. Electrical Power Service Address – Completed.
- j. Signal Construction Notes.
- k. Conductor Schedule
 - (1) Fill in the cable or conductor quantities
 - (2) Modify the Conductor Schedule Table as required of names of cables/conductors specifically for the project.

Add details (If applicable).



NOTES:

1. Permissive through, left and right turn movements are always even numbered.
2. Protective left turn movements are odd numbered.

FIGURE 1-1 – MCDOT Standard 8-Phase Movements

2. PRE-DESIGN REQUIREMENTS

A. DETERMINE JURISDICTION

At least 50% of the intersection should be in the County jurisdiction to be considered as a candidate for MCDOT ownership, operation, and maintenance responsibilities.

1. If the intersection is less than 100% County jurisdiction, an IGA will be required with the other agencies sharing the intersection.
2. If this is a Developer initiated traffic signal, then it is the Developer's responsibility to investigate existing and proposed jurisdictional control, as other municipalities may have plans for annexation of the intersection.

B. TRAFFIC SIGNAL WARRANT ANALYSIS

Before any traffic signal design begins, a traffic signal warrant study or other study justifying the need for the traffic signal must be approved by MCDOT Traffic Management. The traffic signal warrant study shall be based on the MUTCD traffic signal warrants.

C. LEFT TURN LANES

Left turn lanes are to be constructed prior to installation of a traffic signal or during the construction of the traffic signal.

Protective/Permissive and Protective only phasing is not to be included in the design of new signals or signal upgrades unless warrants are met.

D. OPERATIONAL CHARACTERISTICS

Prior to beginning actual design, the geometric features of the intersection, including lane alignment, intersection widths, design vehicle are to be evaluated to determine if any movements will require split phasing, lead/lag, or other unique types of phasing.

3. DESIGN PROCESS

A traffic signal design is initiated either by (1) MCDOT recognizing the need for a new or revised traffic signal within its construction programming process or by (2) a Developer lead construction project that will result in the need for a new or revised traffic signal. The design process for the two can be quite different.

A. CRITICAL PATH DESIGN ISSUES

Several issues in the design will tend to require additional lead time to be completed in time for construction. These issues often take longer to resolve than expected and must be started at the immediate beginning of the project timeline. Some of these issues are as follows:

1. **Railroad Coordination:** If in the vicinity of a Railroad, the project may require easements, pre-emption tie-in, or utility relocations.
2. **Emergency Vehicle Pre-emption Coordination:** Installation of emergency vehicle pre-emption equipment requires an IGA and the pre-emption equipment is to be provided by local jurisdiction or emergency response department.
3. **Right-of-way:** New right-of-way or easements may be required to install new foundations, equipment, or conduit.
4. **Point of Service Coordination:** If new electrical service is required, the electrical utility will need to be contacted to request new service. This can also affect where the service pedestal and traffic signal control cabinet is located.
5. **Utility Coordination:** If any existing utilities are in conflict with the proposed traffic signal, the utilities may require relocation which can take a long time with some utilities
6. **Equipment Supply:** The lead time for traffic signal equipment purchases can sometimes be longer than the construction schedule. MCDOT does not provide materials for Permit work.
7. **ITS Coordination:** Requirements for fiber optic conduit, wireless communication such as CCTV, and other ITS facilities shall be coordinated with the Traffic Management ITS Group.

B. MCDOT LEAD DESIGN PROCESS

The design process includes multiple submittal stages (Scoping, Pre-Final, and Final), with review at each stage. This allows for comprehensive design and conflict resolution.

A scoping letter with accompanying plans will be required with approval, before design of Final plans can begin. As part of the scoping submittal, MCDOT will conduct signal pole foundation excavations to ensure there are no utility or other unknown underground conflicts with the foundations.

C. DEVELOPER LEAD DESIGN PROCESS

The Developer design process requires the initial submittal to be complete, sealed, and buildable construction plans together with a traffic signal warrant study or other study justifying the need for the traffic signal. The plans will be approved or returned to the Developer with comments.

4. TRAFFIC SIGNAL POLE PLACEMENT

A. GENERAL PLACEMENT CRITERIA

1. Traffic signal poles are to be located to provide for the best visibility of signal faces and to avoid confusion.
2. Clear zone requirements. Signal poles are not to be installed on break away bases.
3. Right-of-way restrictions.
4. Intersection lane configuration.
5. Existing and proposed underground and overhead utilities.
6. Drainage structures, bridges, and embankments.
7. Location of buildings, walls, fences and other structures.
8. Tree and landscaping modifications.
9. Geometric alignment of the intersection, particularly for skewed intersections.
10. Reasonableness of curb ramp locations.
11. Poles are not to be placed in sidewalks. An exception may be approved when the pole is located outside of the required 4 foot minimum width of a pedestrian access route.

B. VEHICLE SIGNAL POLES

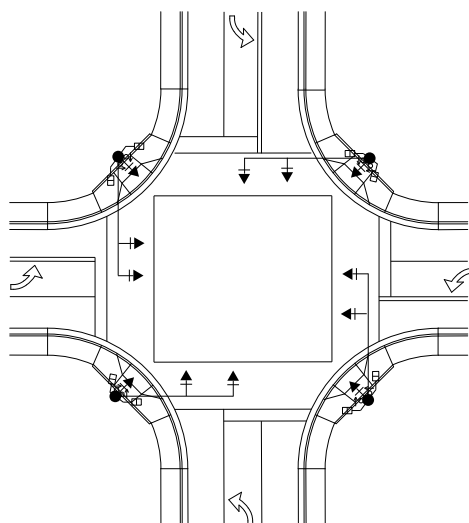
1. An 8-pole configuration is the standard MCDOT signal layout for new or updated signalized intersections.
2. Intersection 4-pole and 6-pole signal configurations are only installed when right of way or utility conflicts restrict the installation of an 8-pole signal configuration. See Figures 4-1 to 4-3 for common signal pole configurations.
3. When feasible vehicle signal poles are to be located at the PC or PT of a curb return.
4. The distance between the stop bar and mast arm heads is to be a minimum of 40' to a maximum of 180'.
5. Use standard mast arm lengths (20', 25', 30', 35' or 40' for Type 'J' and 'Q' poles; 45', 50' or 55' for Type 'K' and 'R' poles).

C. PEDESTRIAN PUSH BUTTON POLES

1. Pedestrian push buttons are preferred to be mounted on signal poles or pedestrian push button poles centered behind curb ramp landings.
2. Alternative locations for pedestrian push buttons are to provide easy access from a level all weather surface.
3. Pedestrian push buttons should be located between the extended crosswalk edge lines and no farther than 5 feet outside of the edge lines.
4. Pedestrian push buttons are to be within 10 feet of the edge of curb or pavement.
5. Use a 14' Type 'A' pole for installations of pedestrian head plus a push button station. Use 16' Type 'A' poles for left side approach and median installations

D. POLES FOR INTERSECTION LIGHTING

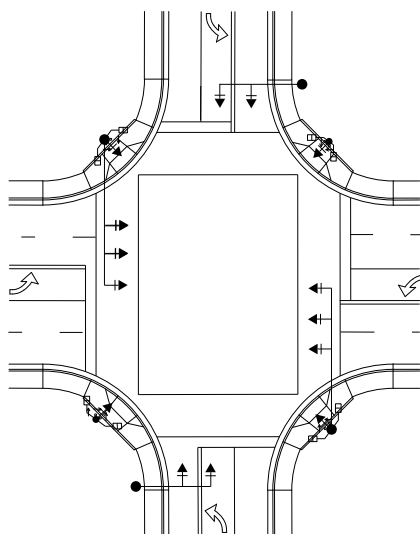
1. Street lighting coverage provided for the entire intersection.
2. Luminaires are to be positioned to illuminate pedestrians within crosswalks.



NOTES:

1. 4-Pole configuration will be used only in extreme cases, where right of way is restrictive and utility conflicts occur.
2. 4-Pole configuration should be avoided due to the excessive mounting of signal equipment on one pole.

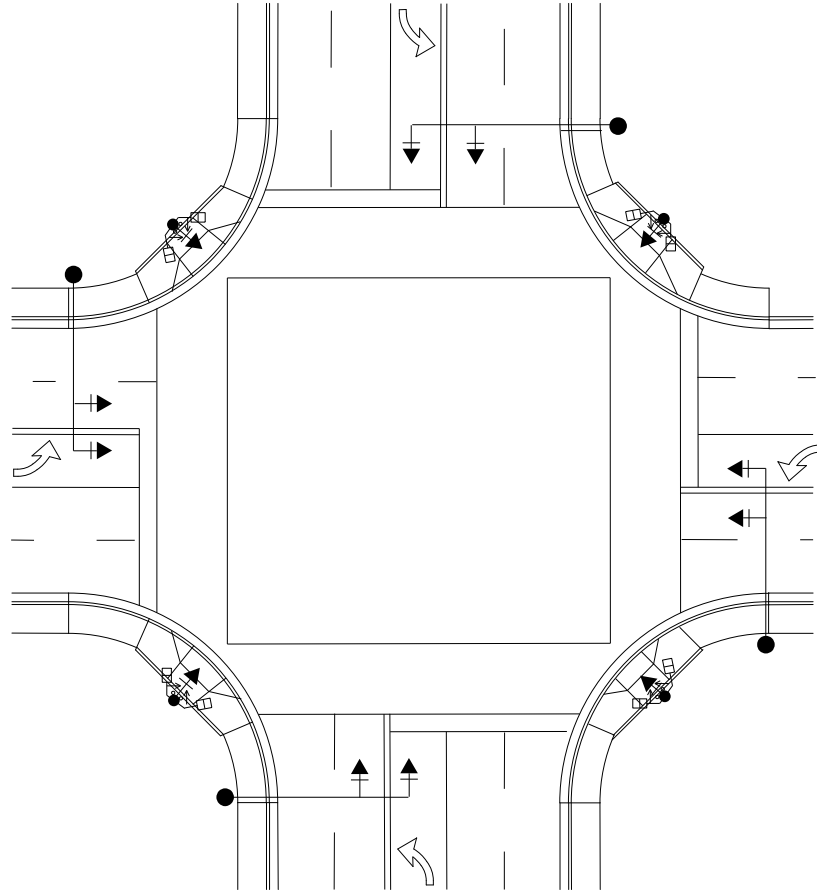
FIGURE 4-1 – 4-POLE TRAFFIC SIGNAL



NOTES:

1. 6-Pole configuration is generally used for arterial to collector intersections.
2. 6-Pole configuration is used when existing right of way is restrictive and utility conflicts occur.
3. When feasible signal poles are to be centered on a curb ramp or located at PC or PT of a curb return. Pedestrian push buttons are to be located on poles centered behind curb ramp landings.

FIGURE 4-2 – 6-POLE TRAFFIC SIGNAL



NOTES:

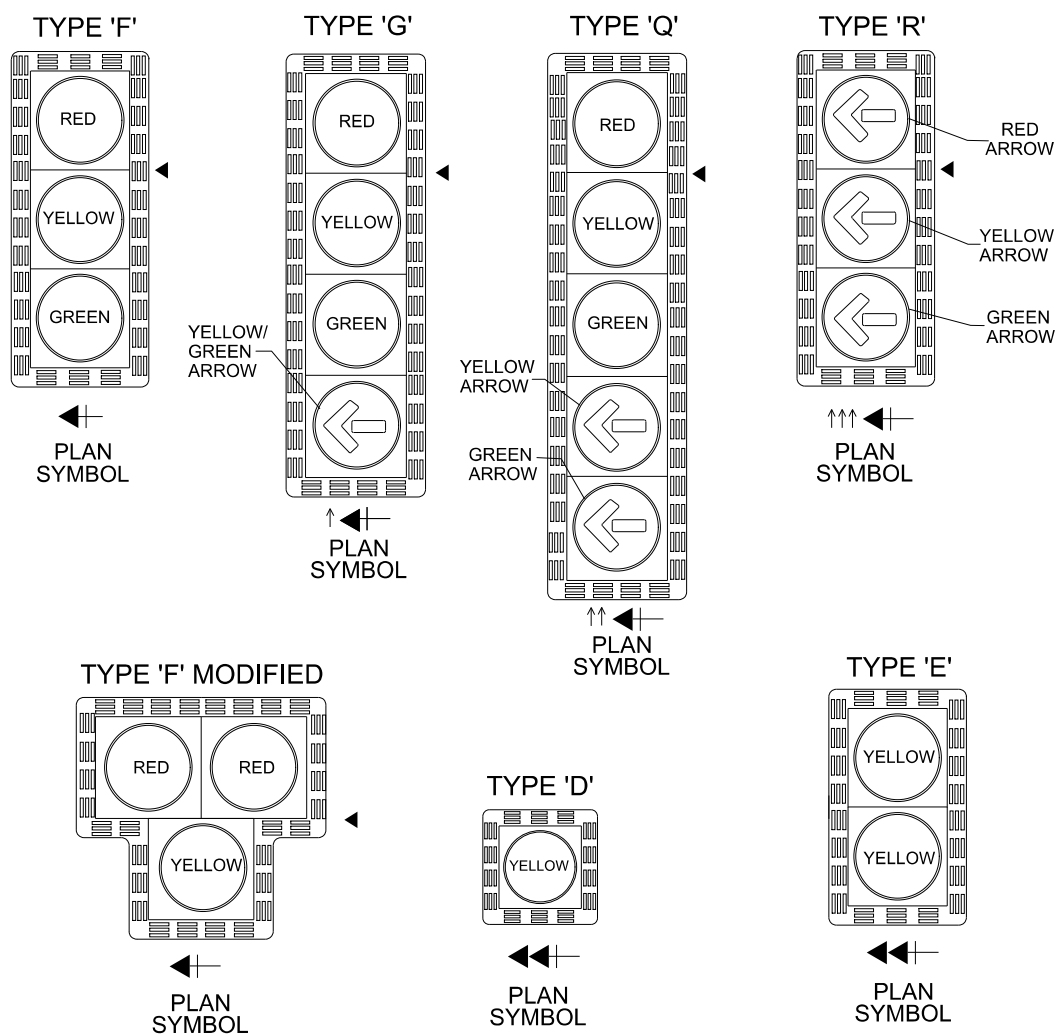
1. 8-Pole configuration is generally used for arterial to collector intersections.
2. When feasible signal poles are to be centered behind the curb at the PC or PT of a curb return. Pedestrian push buttons are to be located on poles centered behind curb ramp landings.

FIGURE 4-3 – 8-POLE TRAFFIC SIGNAL

5. TRAFFIC SIGNAL FACES AND MOUNTING HARDWARE

A. TRAFFIC SIGNAL FACES

1. Upgraded and new traffic signals faces installed at signalized intersections shall be Type F, Type F Modified, G, Q, or R. See Figure 5-1 for traffic signal faces and plan symbols.
2. Traffic signal faces installed for signal flashing beacons are types D and E. See OTHER TRAFFIC SIGNAL INSTALLATIONS in this manual.
3. Optically programmed or louvered heads may be used when the site physical geometry or operational problems require their use. Approval from MCDOT is to be obtained prior to the use of optically programmed or louvered heads.



NOTES:

1. The symbol ◀ denotes location of elevator plumbizer (Type XI) mounting for mast arm installations.
2. All signal arrangements are to be furnished with louvered backplates.

FIGURE 5-1 – TRAFFIC SIGNAL FACES

B. STANDARD USES FOR TRAFFIC SIGNAL FACES

Through, left and right turn movements at signalized intersections are made in three operational modes:

- Permissive Only
- Protected/Permissive
- Protected Only

1. Permissive Only:

- a. Type F signal faces are installed for through movements.
- b. Type F signal faces are installed where left and right turning movements do not meet MCDOT protective turning movement requirements.

2. Protected/Permissive:

Protected/permissive operation represents a combination of the permissive and protected modes. Turning movements have the right of way during the protected phase. Then the turning movements can be completed when there is a sufficient gap from the opposing traffic.

- a. Types G and Q signal faces are installed under the Protected/Permissive mode. The signal faces are installed at the far left location and at the outboard location on the signal mast arm.
- b. Types G and Q Signal faces are installed when the MCDOT – Traffic Management’s “Left Turn Signal Phasing Study” warrants are met.

3. Protected Only:

For protected only criteria, see MCDOT-Traffic Management Procedure #P8205, “LEFT TURN PHASING STUDY”.

- a. Type R signal faces are installed only at the protected mode.
- b. Type R signal faces are installed for dual lefts or dual rights turning lanes.
- c. Type R signal faces are installed when inadequate horizontal or vertical site distances exist.
- d. Type R signal faces are installed at the discretion of the MCDOT Traffic Management Division Manage based on crash history involving turning movements, turning movement volumes, or other conditions.

Type D and E signal faces are used as flashing beacons.

C. PLACEMENT OF TRAFFIC SIGNAL FACES

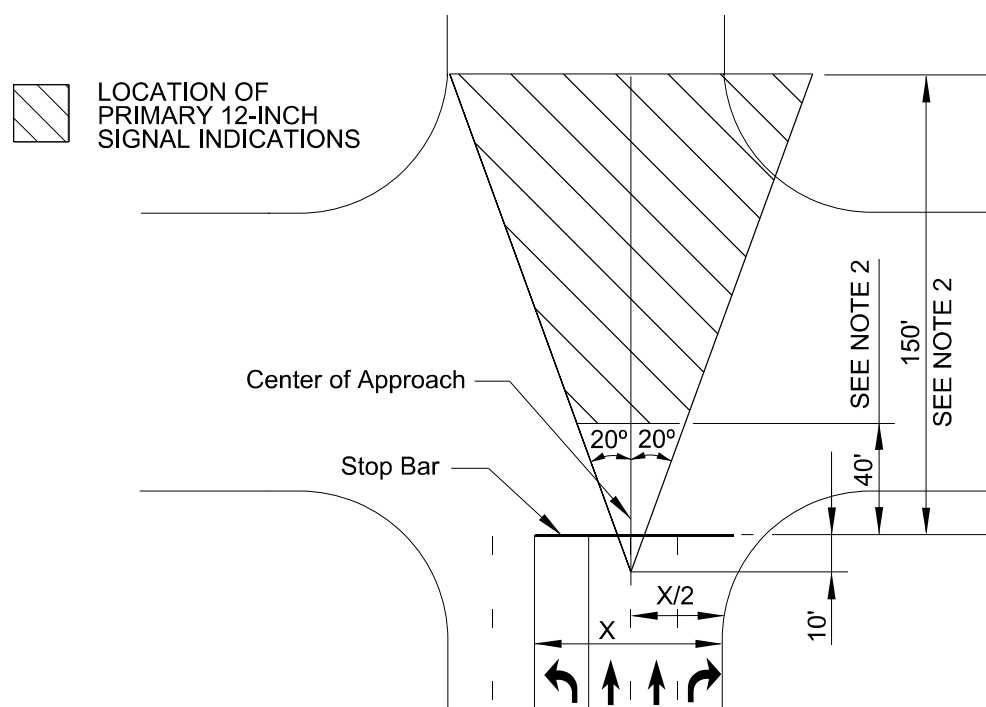
The requirements of the latest edition of the MUTCD and any subsequent editions or revisions shall be met.

1. Traffic signal faces are to be spaced at 12 foot intervals unless otherwise directed.
2. Traffic signal faces are not to obstruct the visibility of other signal faces. Visibility obstructions are to be check, particularly for traffic signal faces on the ends of mast arms.

3. Provide one overhead signal face per through lane and one overhead signal face per turn lane that is not controlled by a turn signal head. Two overhead signal faces at a minimum are required for each approach. See Figure 5-2 for lateral and longitudinal location of signal heads.
4. Position the overhead traffic signal faces to be centered over the lanes, when feasible.
5. Provide two signal faces for left turn lanes:
 - a. Single left-turn lane – Provide one overhead face positioned right of center of the left turn lane. Provide a second face on the traffic signal mast arm on the far left intersection corner, or on a Type A pole or street light pole near the stop line for opposing traffic.
 - b. Dual left-turn lane – Provide one overhead signal face aligned right of center of the rightmost left turn lane. Provide a second face on the traffic signal mast arm pole on the far left intersection corner, or on a Type A pole or street light pole near the stop line for opposing traffic.
6. Provide two signal faces for right-turn lanes with right-turn signal phasing:
 - a. Provide an overhead signal face aligned with the right side of the right turn lane.
 - b. Provide a near right signal face on the signal mast arm pole or on a Type A pole or street light pole near the stop bar.
7. Additional signal faces may be needed when the view of the normal signal faces are concealed from approaching drivers due to horizontal or vertical alignment.

D. TRAFFIC SIGNAL MOUNTING HARDWARE ASSEMBLIES

All mounting assemblies for traffic signals mounted on mast arms and poles are to conform to MCDOT Standard Details.



NOTES:

1. At least one and preferably both of the minimum of the two primary signal faces required for the through movement on the approach shall be located between two lines intersecting with the center approach at a point 10 feet behind the stop bar, one making an angle of 20 degrees to the right of the center of the approach extended, and the other making an angle of 20 degrees to the left of the center of the approach extended.
2. Except where the width of an intersecting roadway or other conditions make it physically impractical, the signal faces for each approach to an intersection or midblock location shall be installed to satisfy the requirements for the primary left turn signal faces and the primary right turn signal faces. At least one and preferably both of the required two primary signal faces for the through movement are to be a minimum of 40 feet beyond the stop bar. When a primary signal face is 150 feet or more beyond the stop bar, a supplemental nearside signal face shall be provided as near a practical into the driver's normal line of sight, mounted over the roadway.

FIGURE 5-2 – LATERAL AND LONGITUDINAL LOCATION OF SIGNAL HEADS

6. PEDESTRIAN CONTROL FEATURES

Pedestrian control features are required to meet ADA accessibility standards.

A. PEDESTRIAN SIGNALS

Pedestrian signals are normally provided on all legs at all signalized intersections.

B. ACCESSIBLE PEDESTRIAN SIGNALS

1. Accessible Pedestrian Signals communicate with pedestrians via audible or vibratory means. They are described in the MUTCD.
2. Upon request, MCDOT will conduct an engineering study at an intersection, considering the safety and operations for pedestrians, including consideration of pedestrians with visual disabilities.
3. Accessible pedestrian signals are to conform with MUTCD requirements.

C. PLACEMENT OF PEDESTRIAN SIGNAL HEADS AND DETECTORS

1. Pedestrian push button installations are to be located in accordance with ADA requirements; this may require mounting on a pole other than a traffic signal pole.
2. The pedestrian push button shall be located adjacent to the landing on the sidewalk area leading to the crosswalk.
3. The pedestrian push button shall be located no further than 5 feet from the extension of the crosswalk lines and within 10 feet of the curb line, unless the curb ramp is longer than 10 feet.
4. For dual curb ramps provide two pedestrian push buttons, one for each crossing. Separate the buttons by at least 10 feet by placing on different poles, pedestrian push button poles may be used.
5. The control face of the push button is to be parallel to the direction of the crosswalk controlled by the push button, and no closer than 30 inches to the curb line.
6. Include pedestrian push button stations in medians when the medians provide a refuge area and the pedestrian phase requires actuation. Use pedestrian push button posts, or locate buttons on Type 'A' poles.
7. Pedestrian signal heads are to be placed to maximize the visibility of the signal head indication for the pedestrian in the crosswalk.

D. OTHER PEDESTRIAN CONTROL FEATURES

1. Pedestrian push button signing is to be per MCDOT Standard Details.
2. Mounting assemblies for pedestrian signal indications are to be Type XI mounts.

7. LIGHTING REQUIREMENTS FOR TRAFFIC SIGNAL INSTALLATIONS

Intersection lighting is typically included at signalized intersections.

A. POLE MOUNTING FOR INTERSECTION LIGHTING

Illuminate each approach. At a minimum, utilize one luminaire for each leg of the intersection which normally would be located on the upper mast arm of an F, Q, or R pole. Conditions may require two luminaires per corner, in which case the additional luminaire is to be mounted on a Type 'F' pole.

B. LUMINAIRES, PHOTO ELECTRIC CELL, AND POWER SOURCE

1. Intersection lighting shall use 120 volt, 250 watt, high pressure sodium luminaires with horizontal cut-off lenses. When directed by MCDOT, a 120 volt (250 watt equivalent) LED luminaire, meeting MCDOT specifications, shall be used.
2. The street lighting photo electric cell shall be mounted on the control cabinet.
3. Power for the street lighting is to come from the traffic signal control cabinet.

9. VEHICLE DETECTION STANDARDS AND GUIDELINES

A. DETECTION TYPES AND CONSIDERATIONS

The guidelines below include the use of both video detection systems and vehicle detection loops, balancing construction and maintenance costs while operating within the reliable range of effectiveness for video detection.

B. DETECTION GUIDELINES

1. Video detection is the type of detection to be used for new traffic signal installations.
2. Isolated Signals
 - a. Use video detection for both major and minor streets.
 - b. Use advance detection loops for both major and minor street approaches based on approach speed.

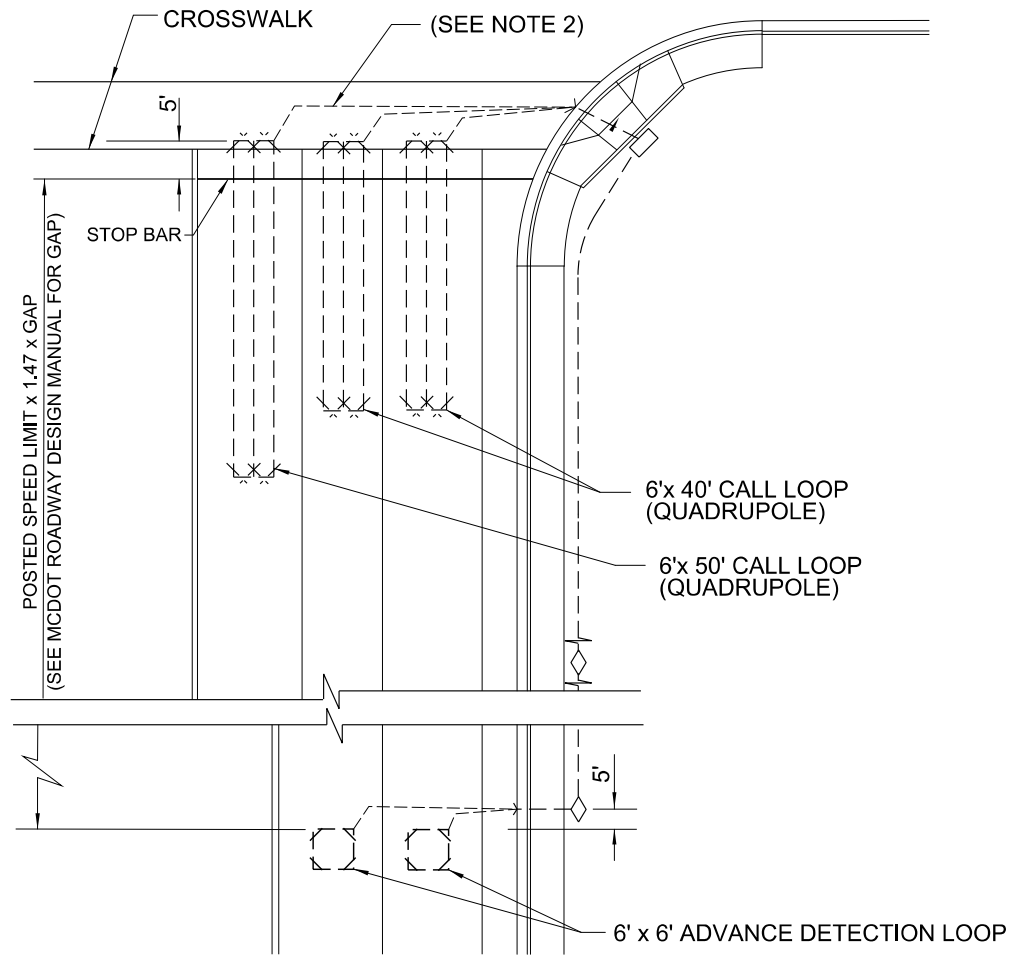
C. VIDEO DETECTION SYSTEM REQUIREMENTS

1. Video detection system equipment shall conform to MCDOT requirements.
2. The contractor shall install and align the video detection cameras and shall provide all field terminations.
3. Cameras are typically mounted on signal mast arms.
4. Cameras are not to be mounted on intersection lighting poles, unless directed by MCDOT.

D. VEHICLE LOOP DETECTION GUIDELINES

Vehicle loop detection is used where horizontal and/or vertical geometries interrupt line of sight, or where glare may be an issue. See Figure 9-1 for typical loop placement.

1. Driveways that function as a minor leg of a signalized intersection may require “call” vehicle detection loops, if video detection is not used.
2. Each loop detector shall have a separate lead-in cable to the controller cabinet.
3. Advance detection loops are connected in series.
4. Advance Loops: Advance loops (6' x 6') are typically used with posted speeds of 45 mph or greater, in advance of an intersection to notify the controller of an approaching vehicle. The distance from the center of the stop line to the center of the loop is the distance a vehicle travels in five seconds, based on the posted speed limit.



NOTES:

1. All detector loops shall be centered in painted lane.
2. All call loops (quadrupole) and advance loops shall have separate lead-in sawcuts and wiring from loops to conduit stub-outs.

FIGURE 9-1 – LOOP DETECTOR PLACEMENT

10. CONDUIT AND PULL BOX REQUIREMENTS

A. GENERAL REQUIREMENTS

1. Provide conduit to each corner of the intersection in a ring configuration, under all intersection approaches. See Figure 10-1 for typical conduit and pull box sizes and locations.
2. Provide separate conduit for low-voltage and high-voltage conductors.
 - a. Low voltage conductors include: emergency pre-emption sensor, telephone interconnect, detector cable, and video to the controller cabinet.
 - b. High voltage conductors include: signal and street lighting conductors, photo cell, and bare bond.
3. Number all conduit runs on plan sheet.

B. CONDUIT SIZE AND PLACEMENT

1. Conduit is to be installed by boring when it is to be located under an existing paved roadway or paved driveway that is not scheduled to be reconstructed.
2. When an existing traffic signal is upgraded, the main 3-inch ring configuration conduit runs shall not be extended from the existing pull box locations. Conduit runs shall be replaced with new conduit runs between # 7 pull boxes.
3. The typical signalized intersection is boxed with two (2) three inch conduits (2-3"), one for low voltage and one for high voltage.
4. If a Type A signal pole is to be installed in a raised median, a two inch (2) conduit shall run from the Type A pole to the nearest corner #7 pull box.

C. PULL BOX SIZE AND PLACEMENT

1. A No. 7 pull box with extension is to be installed on the same corner as the traffic signal controller cabinet.
2. For all other corners, typically a No.7 pull box is installed.
3. If a pull box is required in the median it shall be a No. 5 pull box, except for advance detection cable.
4. Install No. 3 ½ pull boxes in medians or shoulders for advance detection cable.
5. Pull boxes are not to be located in drainage areas susceptible to water immersion or flooding.
6. Pull boxes shall not be installed within concrete curb ramps or sidewalks. Pull boxes installed behind curbs shall be installed between the curb and the proposed/future sidewalk or beyond the proposed/future sidewalk.
7. Pull boxes installed along an uncurbed roadway are to be located within one foot of the outer edge of the shoulder.
8. See MCDOT Standard Detail Nos. 4711, 4712, and 4713 for pull box requirements.
9. When connection to ITS fiber optic cable is required install 2-inch conduit to connect fiber optic pull box to traffic signal controller foundation. See Figure 11-2 for ITS conduit and pull box.

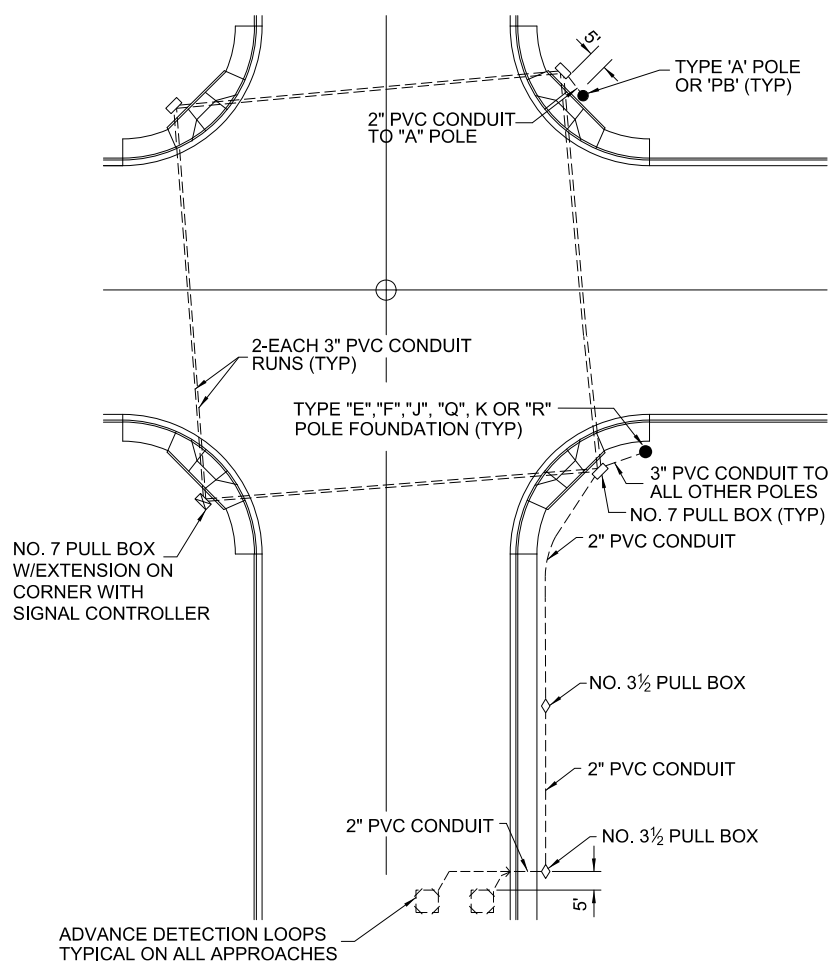


FIGURE 10-1 – TYPICAL PULL BOXES AND CONDUIT

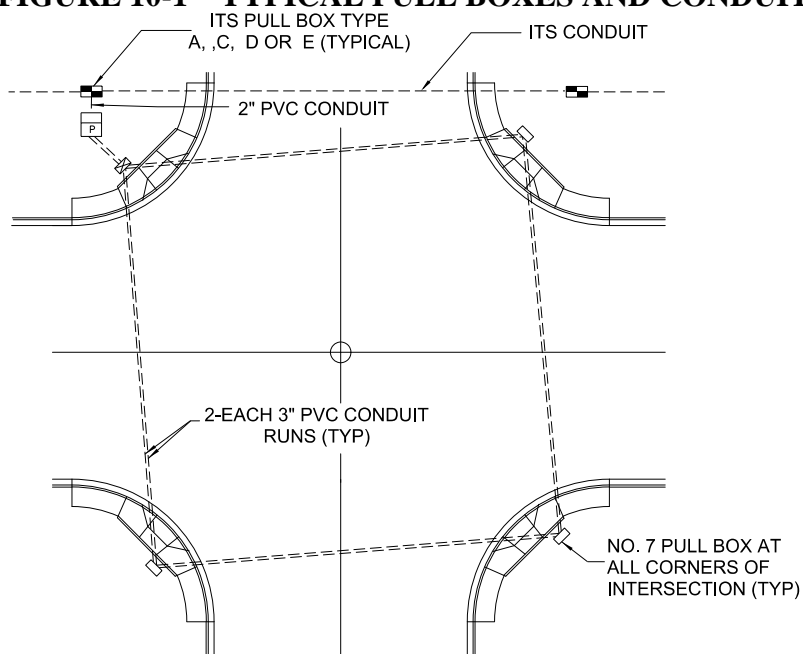


FIGURE 10-2 – TYPICAL ITS PULL BOXES AND CONDUIT

11. OTHER TRAFFIC SIGNAL RELATED EQUIPMENT

A. EMERGENCY VEHICLE PRE-EMPTION SYSTEMS

1. Emergency Vehicle Pre-Emption Equipment shall be provided by local jurisdiction or emergency response department and installed on MCDOT signal per IGA.
2. All MCDOT traffic signal designs may include Emergency Vehicle Pre-emption Systems. These systems include detectors, beacons and associated wiring and cabling.
3. Beacons and detectors shall be centered between the Signal head at the signal mast arm tip and the first inboard signal head.

B. METRO STREET NAME SIGNS

1. Metro street name signs are installed on all new and modified MCDOT signals. Metro Street Name Signs are to be attached to the major signal pole for each approach to the intersection.
2. Refer to the current MCDOT Signing Manual for additional information related to street name signs.
3. See Figure 11-1 for metro street name sign layout to be used on all traffic signal plans.

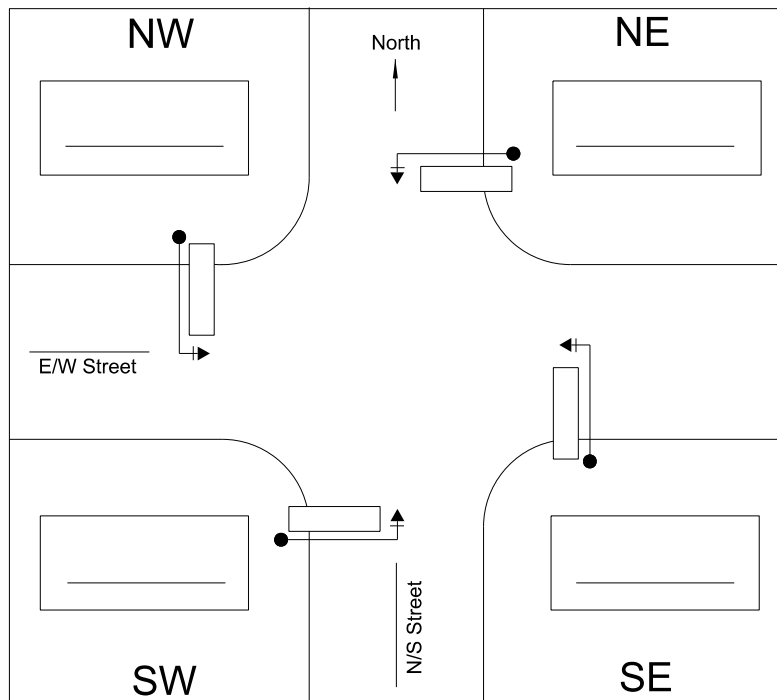


FIGURE 11-1 – TYPICAL METRO STREET NAME SIGN INSTALLATION

12. OTHER TRAFFIC SIGNAL INSTALLATIONS

All installations are to be in conformance with the Manual on Uniform Traffic Control Devices (MUTCD).

A. INTERSECTION CONTROL BEACONS

1. An intersection control beacon is used only at an intersection to control two or more directions of travel. It consists of one or more signal faces directed toward each approach to the intersection, flashing circular yellow or circular red signal indications.
2. Intersection control beacons may be used at intersections where traffic or physical conditions do not justify conventional traffic control signals but crash rates indicate the possibility of special need.

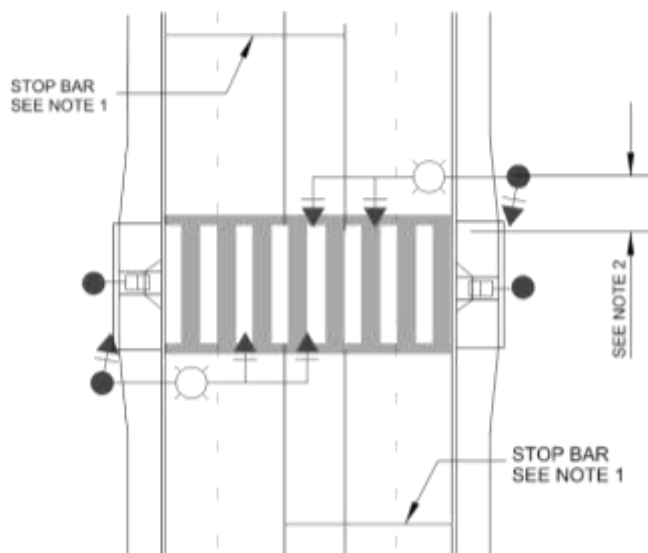
B. WARNING BEACONS

1. A warning beacon may be used to supplement an appropriate warning or regulatory sign or marker, and consists of one or more signal sections of a standard traffic signal face with a flashing circular yellow signal indication in each signal section.
2. Typical applications of warning beacons may include:
 - a. At obstructions in or immediately adjacent to the roadway.
 - b. As supplemental emphasis to warning signs.
 - c. On approaches to intersections where additional warning is required, or where special conditions exist.
 - d. The condition or regulation justifying warning beacons should largely govern their location with respect to the roadway.
 - e. Warning beacons are to be operated only during those periods when the condition or regulation exists.
3. Use 18' Type 'A' poles for advanced flashers approaching a signalized intersection.

C. PEDESTRIAN HYBRID BEACON (HAWK)

1. A HAWK crossing is a pedestrian-actuated traffic control device, used to alert and stop motorists in order to permit pedestrians to cross the street safely.
2. HAWK crossings shall use high visibility crosswalks.
3. The following signal equipment and materials are required to install a Pedestrian Hybrid Beacon:
 - a. Signal pole with an appropriate mast arm length. (Each approach)
 - b. Roadway light fixture and luminaire mast arm. (Each approach)
 - c. 2-Aerial mount Type 'F' modified signal indication. (Each approach)
 - d. 1-Side mount Type 'F' modified signal indication. (Each approach)
 - e. Required traffic signs mounted on signal poles, see Figure 12-3.
 - f. 1-Controller cabinet and foundation.
 - g. 1-Combination service pedestal/battery backup cabinet system with foundation.

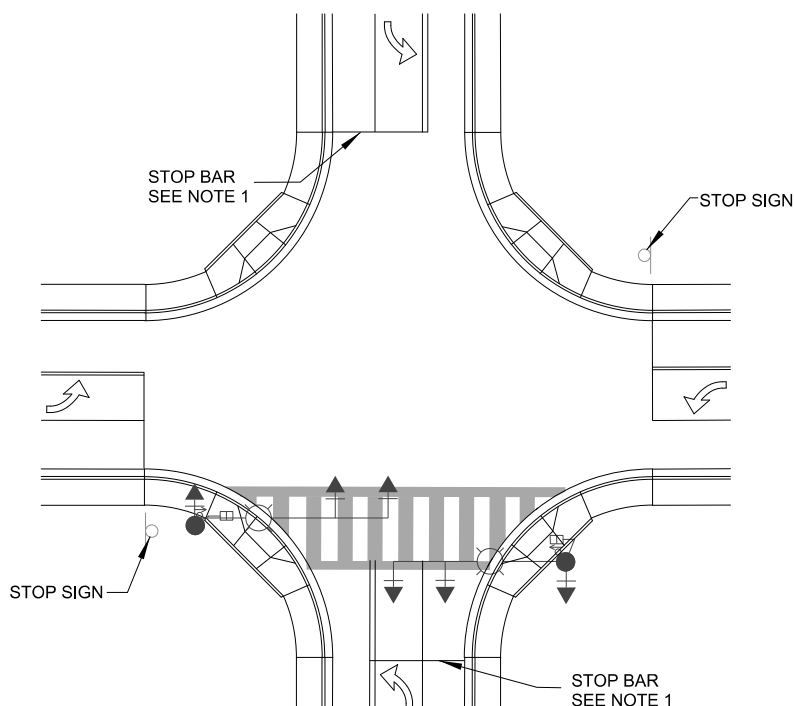
- h. 2-3" Conduit runs across roadway.
- i. 2-#7 Pull boxes.
- j. Two 14' Type A signal poles with pedestrian signal indications and pedestrian push button stations with signs.



NOTES:

1. See MCDOT Pavement Marking Manual for striping requirements.
2. When the distance between the edge of the crosswalk and center of the signal mast arm is greater than ten feet, a secondary signal pole and pedestrian equipment shall be installed at the center of the curb ramp.

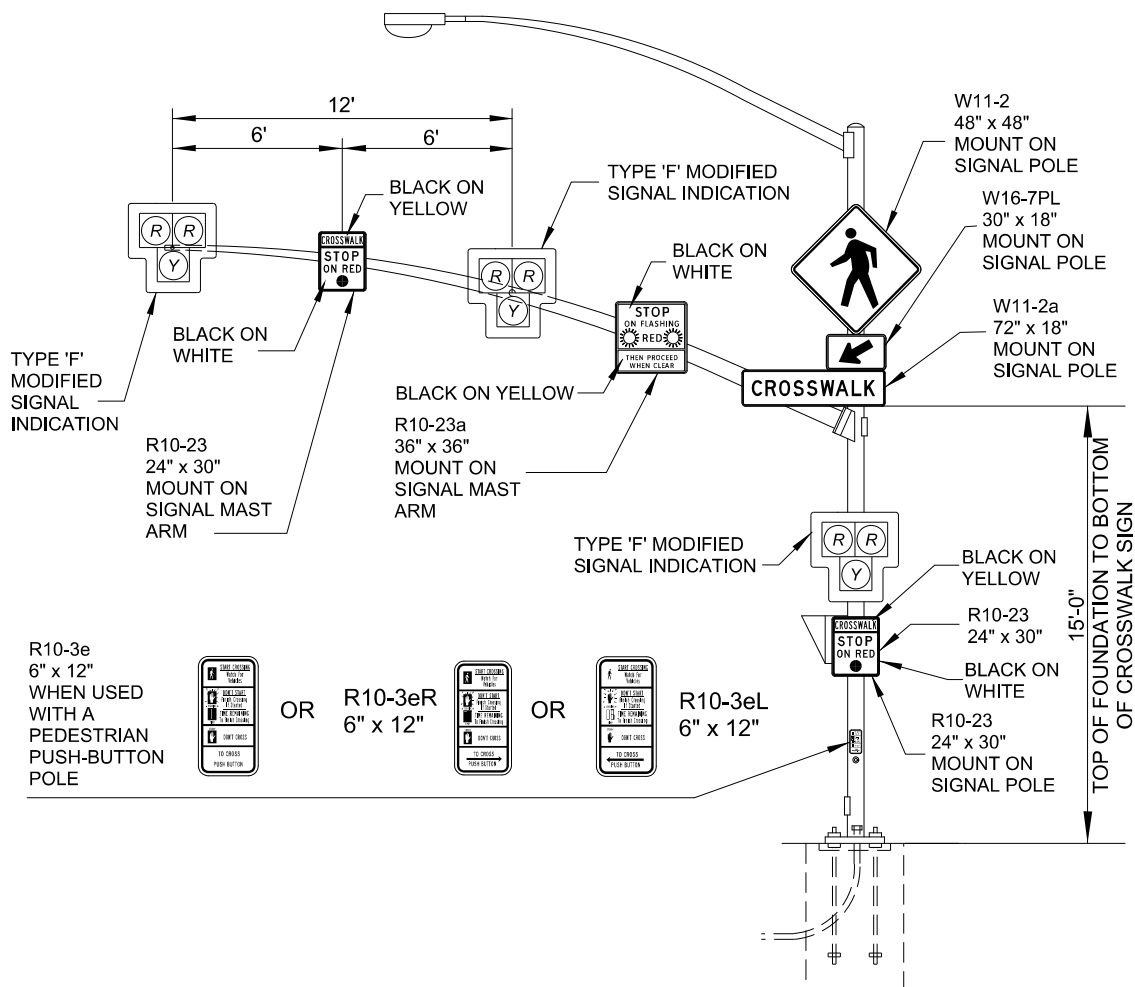
FIGURE 12-1 – MIDBLOCK PEDESTRIAN HYBRID BEACON LAYOUT



NOTES:

1. See MCDOT Pavement Marking Manual for striping requirements.

FIGURE 12-2 – INTERSECTION LAYOUT FOR PEDESTRIAN HYBRID BEACON



NOTES:

1. The W11-2a sign shall be attached to the signal pole per MCDOT Detail 4780-2.
2. When installed with a pedestrian hybrid beacon the retroreflective sheeting type for the W11-2, W11-2a, W16-7PL, and R10-23 is to be diamond grade.

FIGURE 12-3 – PEDESTRIAN HYBRID BEACON INSTALLATION



[illegible]

APPENDIX B – General Traffic Signal Notes

1. THE INSTALLATION OF ALL SIGNAL EQUIPMENT AND MATERIALS SHALL CONFORM TO THE MCDOT SUPPLEMENT TO THE MARICOPA ASSOCIATION OF GOVERNMENTS (MAG) UNIFORM STANDARD SPECIFICATIONS AND DETAILS FOR PUBLIC WORKS CONSTRUCTION, SECTIONS 470 TO 478, THESE PLANS AND ACCOMPANYING SPECIAL PROVISIONS.
2. THE CONTRACTOR SHALL CONTACT “BLUE STAKE” AT 602-623-1100 PRIOR TO START OF WORK.
3. THE LOCATIONS OF UTILITIES SHOWN ON THE PLANS ARE APPROXIMATE. ALL UTILITIES MAY NOT BE SHOWN. THE CONTRACTOR SHALL FIELD VERIFY ALL UTILITY LOCATIONS PRIOR TO PROCEEDING WITH CONSTRUCTION ACTIVITIES.
4. ALL POLE, CONTROLLER, BATTERY BACKUP AND CABINET FOUNDATIONS SHOWN ON THE PLANS ARE SUBJECT TO LOCATION ADJUSTMENT IF A FIELD CONFLICT IS ENCOUNTERED. THE CONTRACTOR SHALL CONTACT THE TRAFFIC SIGNAL BRANCH AT 602-506-8680 TO REVIEW ALL LOCATION ADJUSTMENTS FOR TRAFFIC SIGNAL FOUNDATIONS.

APPENDIX C – Signal Design Checklist

Project Name:

Location:

Consultant:

Phone:

Fax:

Plans Sealed By:

Project No.

DESIGN (Designed By: _____ Date: _____)

#	CHECK LIST: Check All That Apply	YES	NO	N/A
1	Is this a new signal (____) or an existing signal to be modified (____)?			
2	Check for signal sight distance for all approaches.			
3	Check for intersection geometrics, median and ramp locations, plan/profile, striping plans.			
4	Check R/W. All signal equipment needs to be within existing R/W.			
5	Check jurisdictional limits for any construction permits that may be required.			
6	For new signal installations, determine power service area (APS or SRP)			
7	Check phasing of signal (use 2 and 6 for the major street)			
8	Check orientation of median noses, ramps, crosswalks, and stop bars.			
9	Check clear zone issues. Poles should be 8' minimum from edge of roadway, 10' preferred.			
10	Check minimum clearance of 2' from outside of pole foundation to any underground utilities			
11	Check for clearance to overhead power lines. Minimum distance from poles to power lines is generally (10'), horizontal/vertical, maybe more w/higher voltage.			
12	Check for minimum 2' separation from new underground conduit to existing utility			
13	Check calculations used for station and offset distance to the center of signal pole foundations, cabinet foundations and service pedestal foundations.			
14	Check elevations of pole foundations. Top of foundations should match top of curb			
15	Check signal head placement, one head per lane and centered over lane.			
16	Check signal head orientation for both close to and far from intersection. Minimum distance (40') from stop bar; Maximum (150'). If more than (150'), require an additional near head.			
17	Check the Metro Street signs are included with new traffic signals. If existing signal is modified, check for signing changes.			
18	Check pedestrian signal heads and push button stations are included in signal installation.			
19	Check placement of pedestrian push button stations for ADA compliance.			
20	Check detection; Determine detection for new signal (loops or video), check detection for existing signal.			
	If loops, check quadrupole presence and advance placement locations with respect to stop bars. Check all loops are centered in lanes. Basic loop requirements:			
	a. Quadrupole loops (6' x 50') used for all left turn lanes. Loops placed (5') past stop bar into intersection.			
	b. Quadrupole loops (6' x 40') used for all thru lanes. Loops placed (5') past stop bar into intersection.			
	c. Advance loops (6'x6') are placed at the calculated distance from stop bar to front of loop (Formula: MPH x 1.47 x GAP) Gap = (5) sec. passage time.			
21	Check for streetlight coverage. One luminaire for each intersection leg.			
22	Check pull box locations for utility conflicts, check plan station and offset.			
23	Check point of service. Utility company should bring to R/W line			
24	Check control cabinet location for door accessibility and visibility of intersection.			
25	Check tables for proper callouts, summary of materials and quantities.			
26	Check Conductor Schedule indicates correct wire/cable type, size and number of conductors.			
27	Check usage of 20,7,4 and 2 conductor cables.			
28	Check correct phase numbers are indicated on the plan sheets for each signal and pedestrian phase. Use phase 2 and 6 for the major street.			
29	Check service address is included in new traffic signal or relocated service.			
30	Check signal wiring is to be re-pulled or install new wiring.			